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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/881,408	06/13/2001	Kie Y. Ahn	MI22-1534	8492

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EXAMINER
LE, THAO X

ART UNIT	PAPER NUMBER
2814	

DATE MAILED: 07/26/2002

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No. 09/881,408	Applicant(s) AHN ET AL.	
	Examiner Thao X Le	Art Unit 2814	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *28 May 2002* .

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-31 and 52-55* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-9,13-31 and 52-55* is/are rejected.

7)☒ Claim(s) *10-12 and 28* is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

11)☐ The proposed drawing correction filed on _____ is: a)☐ approved b)☐ disapproved by the Examiner.

If approved, corrected drawings are required in reply to this Office action.

12)☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

13)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____ .

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).

a) ☐ The translation of the foreign language provisional application has been received.

15)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO-1449) Paper No(s) _____ .
4) ☐ Interview Summary (PTO-413) Paper No(s). _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: .

DETAILED ACTION

1. Cancelled claim 32-51 in Paper No. 8 is acknowledged.

Claim Rejections - 35 USC § 102

2. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (e) the invention was described in-
> (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effect under this subsection of a national application published under section 122(b) only if the international application designating the United States was published under Article 21(2)(a) of such treaty in the English language; or
> (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that a patent shall not be deemed filed in the United States for the purposes of this subsection based on the filing of an international application filed under the treaty defined in section 351(a).

3. Claims52, 54 are rejected under 35 U.S.C. 102(e) as being anticipated by Pub. No.: U.S 2001/0013629 to Bai.

Regarding to claim 52, Bai reference teaches a method of forming a dielectric layer comprising: providing a substrate 105 comprising a silicon-containing surface [0016], forming a first metal-containing dielectric layer 130 over the surface, the metal comprising an element selected from group IVB of the periodic table [0018], forming a second metal-containing dielectric layer (a third dielectric layer) on the first metal-containing dielectric layer, the second dielectric layer comprising an element selected from Group IIIB of the periodic table, [0027] fig.1.

Regarding to claim 54, Bai reference teaches a method of forming a MOS transistor, comprising: providing a semiconductor substrate 105 having a surface comprising a silicon

[0016], forming a hafnium-containing dielectric layer 130 overlying the surface, forming a lanthanum-containing dielectric layer, (as third dielectric layer), [0027], on hafnium-containing dielectric layer, and forming a gate electrode 110, [0016] over the hafnium-containing and lanthanum-containing dielectric layers, fig. 1

Claim Rejections - 35 USC § 103

4. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

5. Claim 1-7, 19 are rejected under 35 U.S.C. 103(a) as being unpatentable over US Pub. 2001/0013629 to Bai, and further in view of US Patent 6,184,072 to Kaushik et al.

Regarding to claims 1, 4 Bai reference teaches a method of forming a dielectric layer comprising: a substrate 105, [0016], comprising a silicon-containing surface, forming metal oxide as a first metal-containing dielectric layer 130, [0018], over the surface, the metal comprising an element selected from group IVB of the periodic table, forming a second metal-containing dielectric layer (third dielectric), [0027], over the first metal-containing dielectric layer. See fig.1.

But, Bai does not expressly disclose forming a silicon dioxide layer overlying at least one portion of the surface, forming the a metal layer over the layer of the silicon dioxide; combining metal of the metal layer with oxygen of the silicon dioxide layer to form a metal oxide as a first metal-containing dielectric layer over the surface.

However, Kaushik reference discloses forming a silicon dioxide layer 14, fig. 1, column 2 line 30 and 60, overlying at least one portion of the surface, forming the a hafnium metal layer 16, fig. 2, column 2 line 47 and column 3 line 2, over the layer of the silicon dioxide; combining metal of the metal layer with oxygen of the silicon dioxide layer to form a metal oxide as a first metal-containing dielectric layer 18, fig. 3, column 3 line 13-30, over the surface, wherein the metal layer comprising an element selected from Group IVB of the periodic table, column 2 line 45-48. At the time of the invention was made; it would have been obvious to one of ordinary skill in the art to combine the metal of metal layer with oxygen of the silicon dioxide layer teaching of Kaushik with Bai method to form a first metal-containing dielectric layer over the surface, because it would have created a high-K dielectric layer as taught by Kaushik, column 3 line 28.

Regarding to claims 2-3 Bai discloses the first metal-containing dielectric layer 130 comprises hafnium, [0018], the second metal-containing dielectric layer (third dielectric layer), [0027], is formed on the first metal-containing dielectric layer, fig. 1.

Regarding to claim 5, Bai does not expressly disclose the combining comprises providing conditions effective to the hafnium of the metal layer to chemically reduce the silicon dioxide layer.

However, Kaushik reference discloses the combining comprises providing conditions effective to the hafnium of the metal layer to chemically reduce the silicon dioxide layer, column 3 lines 13-30. At the time of the invention was made; it would have been obvious to one of ordinary skill in the art to combine the chemically reduce the silicon dioxide layer by hafnium of Kaushik with Bai method, because it would have

achieved an optimal increase in dielectric constant as taught by Kaushik, column 3 line 11.

Regarding to claims 6-7, Bai discloses a method wherein the second metal-containing dielectric layer comprises an element selected from the Group IIIB of the periodic table, wherein the second metal-containing dielectric layer comprises lanthanum, [0027].

Regarding to claim 19, Bai discloses the method wherein the first metal-containing dielectric layer 130 consist of hafnium oxide, [0018], and the second metal-containing dielectric layer consists of lanthanum oxide (third dielectric layer), [0027]

6. Claims 8-9, 13-15, 16, 18, 20-24, 26-27, 29-31, 53, 55 are rejected under 35 U.S.C. 103(a) as being unpatentable over US Pub. 2001/0013629 to Bai and US Patent 6,184,072 to Kaushik et al. as applied to claim 1 above, and further in view of US Patent 6,399,521 to Zhang et al.

Regarding to claims 8, 24, 27 as discussed in claim 1, the combination of Bai and Kaushik disclose all the limitations in claim 8, except they do not expressly disclose exposing the hafnium-containing layer and the lanthanum-containing layer to an oxygen comprising atmosphere and heating the hafnium-containing layer and the lanthanum-containing layer to a temperature effective to form a hafnium-containing dielectric layer and a lanthanum-containing dielectric layer.

However, Zhang reference discloses exposing to an oxygen comprising atmosphere, column 6 line 25-34. At the time of the invention was made; it would have been obvious to one of ordinary skill in the art to combine the exposing metal-containing

layer to an oxygen comprising atmosphere teaching of Zhang with Bai and Kaushik, because it would have oxidized the metal as taught by Zhang, column 6 line 34.

Regarding to claims 9, 16, Bai discloses the gate dielectric is deposited by conventional techniques such as CVP or others, [0017]. In addition, Kaushik discloses any known method including a sputter (it is also known as physical chemical deposition or PVD), column 3 line 3. Furthermore, Zhang discloses the CVP, PVD, & MOCVD processes to deposit hafnium-containing layer 14 fig. 3, column 5 line 51. At the time of the invention was made; it would have been obvious to one of ordinary skill in the art to select the deposition process as disclosed above, because such processes have been commonly used in the art.

Regarding to claims 13, 14, Bai discloses forming the hafnium-containing dielectric layer 130 (t_1) less than or equal to about 5 nanometer (nm), see table 1, and forming the lanthanum-containing dielectric layer (third dielectric layer), [0027], with various thickness ratio of t, t_1 and t_2, table 1.

But Bai does not expressly disclose depositing the lanthanum to the thickness less than or equal to 5 nm, and a ratio of the hafnium thickness to the lanthanum thickness of about 1 to 3 to about 1 to 4.

However, Kaushik reference discloses forming a metal layer to a thickness less than or equal to about 5 nm, column 3 line 7. At the time of the invention was made; it would have been obvious to one of ordinary skill in the art to combine the metal thickness teaching of Kaushik with Bai method, because such thickness or particular metal will depend upon dielectric constant desired, column 3 line 5.

Regarding to claims 15, 18, Bai's reference does not disclose forming the metal containing dielectric layer and the second metal-containing dielectric layer comprises forming the layer to have respective thickness having a ratio of from about 4:1 to about 1:4.

However, Bai's reference teach different thickness ratio between first and second metal-containing dielectric layer, paragraph [0020-0024] and table 1. Accordingly, it would have been obvious to use the teaching ratio of Bai's method in the range as claimed, because it has been held that where the general conditions of the claims are disclosed in the prior art, it is inventive to discover the optimum or workable range by routine experimentation. See In re Aller, 220 F.2d 454, 105 USPQ 233, 235 (CCPA 1955).

Regarding to claims 20, 22 Bai reference teaches a method for forming a MOS transistor, comprising: providing a semiconductor substrate 105 having a surface comprising silicon, forming a hafnium-containing dielectric layer 130 overlying the surface, including first forming a hafnium-containing layer, [0018], forming a lanthanum-containing dielectric layer (as third dielectric layer) [0027], overlying the hafnium-containing dielectric layer, including second forming a lanthanum-containing layer, and forming a gate electrode 110 over the hafnium-containing and lanthanum-containing dielectric layers, see fig. 1.

But Bai does not disclose the first forming and the second forming encompassing physical vapor deposition comprises electron beam evaporation.

However, Bai discloses the gate dielectric is deposited by conventional techniques such as CVP or others, [0017]. In addition, Kaushik discloses any known method including a sputter (it is also known as physical chemical deposition or PVD),

column 3 line 3. Furthermore, Zhang discloses the CVP, PVD, & MOCVD processes to deposit hafnium-containing layer 14 fig. 3, column 5 line 51. At the time of the invention was made; it would have been obvious to one of ordinary skill in the art to select or use other conventional method such as PVD comprise electron bean evaporation, because these conventional methods have been commonly used in the art.

Regarding to claim 21, Bai disclose the lanthanum-containing dielectric layer is formed on the hafnium-containing dielectric layer, fig. 1.

Regarding to claim 23, as discussed in claim 1 above, the combination of Bai and Kaushik disclose all the limitations in claim 23.

Regarding to claim 25-26, Bai discloses a method wherein the forming the hafnium-containing dielectric layer and the lanthanum-containing comprise forming oxides of hafnium and lanthanum.

But Bai does not disclose the method wherein the heating comprises heating the hafnium and lanthanum containing layers to a temperature from about 200°C and 400°C.

However, Kaushik reference discloses heating the device to a temperature of from about 400°C, column 3 line 20. In addition, Zhang reference discloses the annealing temperature in the range between 400°C to 1000°C, column 6 line 30. Accordingly, it would have been obvious to use temperature teaching of Kaushik and Zhang in the range as claimed, because it has been held that where the general conditions of the claims are discloses in the prior art, it is not inventive to discover the optimum or workable range by routine experimentation. See In re Aller, 220 F.2d 454, 105 USPQ 233, 235 (CCPA 1955).

Regarding to claim 29, as discussed in claim 13-15 above, the combination of prior art disclose all the limitation of claim 29.

Regarding to claim 30, Bai discloses the thickness of the hafnium-containing layer, t_1 in table 1, is no greater than about 1 nm.

Regarding to claim 31, Bai teaches the hafnium-containing dielectric layer 130 and the lanthanum-containing layer (third dielectric layer, paragraph [0027]), where the gate dielectric layer, t_{ox}, is form having an equivalent oxide thickness less than or equal to 2nm, see table 1.

Regarding to claim 53, Bai discloses a method of forming a dielectric layer comprising: providing a substrate 105 comprising a silicon-containing surface [0016], forming a first metal-containing dielectric layer 130 over the surface, the metal comprising an element selected from group IVB of the periodic table [0018], and forming a second metal-containing dielectric layer (a third dielectric layer) over the first metal-containing dielectric layer, [0027] fig.1.

But Bai does not disclose forming a metal layer over the surface, oxidizing the metal layer to form a metal oxide.

However, Zhang reference discloses forming a metal layer over the surface, oxidizing the metal layer to form a metal oxide, column 5 line 57-62. At the time of the invention was made; it would have been obvious to one of ordinary skill in the art to use the annealing teaching of Zhang with Bai, because it would have oxidized the metal as taught by Zhang, column 5 line 61.

Regarding to claim 55, Bai discloses a method for forming a MOS transistor, comprising: providing a semiconductor substrate 105 having a surface comprising a silicon [0016], forming a hafnium-containing layer 130 overlying the surface, forming a lanthanum-containing dielectric

layer, (as third dielectric layer), [0027], overlying the hafnium-containing dielectric layer, and forming a gate electrode 110, [0016] over the hafnium-containing and lanthanum-containing dielectric layers, fig. 1

But Bai does not disclose the method comprising oxidizing the hafnium-containing layer in to a hafnium-containing dielectric layer.

However, Zhang reference discloses oxidizing the hafnium-containing layer in to a hafnium-containing dielectric layer, column 5 line 57-62. At the time of the invention was made; it would have been obvious to one of ordinary skill in the art to use the annealing teaching of Zhang with Bai, because it would have oxidized the metal as taught by Zhang, column 5 line 61.

Allowable Subject Matter

7. Claims 10, 11,12 and 28 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

With respect to claim 10, the prior art of record fails to disclose all the limitation in claim 10, including the exposing comprises ion bombardment of the hafnium layer and the lanthanum-containing layer using and ion bombardment energy of about 10 EV or less.

With respect to claim 11, the prior art of record fails to disclose all the limitation in claim 11, including the heating comprises heating the temperature from about 200°C to about 400°C during the ion bombardment.

With respect to claim 12, the prior art of record fails to disclose all the limitation in claim 12, including the exposing to oxygen radicals.

With respect to claim 28, the prior art fails to disclose all the limitations in claim 80, including providing ion bombardment of the hafnium layer and the lanthanum-containing layer using and ion bombardment energy of about 10 EV or less and where the heating to an effective temperature comprises heating while providing ion bombardment to a temperature from about 200°C to about 400°C.

Response to Arguments

8. With respect to the independent claim 20, the Applicant argues that the express language of claim 20 sets forth forming a hafnium-containing dielectric layer, including first forming a hafnium-containing layer. That is, a difference exists between a hafnium-containing dielectric layer and a hafnium-containing layer. The Examiner respectfully disagrees with the applicant's argument because the Bai reference discloses the hafnium-containing dielectric layer 130, fig. 1, including first forming a hafnium-containing layer. Bai discloses the bottom dielectric layer 130 comprises hafnium oxide, [0018]. The hafnium-containing dielectric layer is the hafnium-containing layer. There is no different. Therefore, Bai's disclosure meets the independent claim 20 limitations.

In addition the Applicant argues that Bai does not disclose forming a lanthanum-containing dielectric layer, including second forming a hafnium-containing layer. The Examiner respectfully disagrees with the applicant's argument because the Bai reference discloses the lanthanum-containing dielectric layer (a third dielectric layer), including second forming a

lanthanum-containing layer. Bai discloses the third dielectric layer comprises lanthanum oxide, [0027]. The lanthanum-containing dielectric layer is the lanthanum-containing layer. There is no different. Therefore, Bai's disclosure meets the independent claim 20 limitations.

Conclusion

9. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

a. US 6207589

b. US 6200893

c. US 6020243

d. US 5346600

e. US 6383873

10. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Thao X Le whose telephone number is 703-306-0208. The examiner can normally be reached on M-T from 7:00 AM - 5:30 PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Olik Chaudhuri can be reached on 703-306-2794. The fax phone numbers for the organization where this application or proceeding is assigned are 703-308-7722 for regular communications and 703-308-7722 for After Final communications.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 703-308-0956.

Thao X. Le
July 23, 2002

PHAT X. CAO
PRIMARY EXAMINER